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Heads

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1. The problem

Recent work on morphology--Lieber (1981), Williams (1981), Kiparsky (1982), and Selkirk (1982), in particular--has extended the notion of *head* from syntax into new areas in morphology. In particular, these writers propose that in forms with derivational affixes, like English *happiness*, the affix is the head of the combination; for instance, Kiparsky assumes (following Lieber) 'that all word formation is endocentric', meaning by this 'that the category of a derived word is always non-distinct from the category of its head, in English usually the rightmost constituent (cf. Williams 1981)' (133).

What makes this proposal attractive is that it allows us to take advantage of a general principle, called Percolation by most of these writers, which requires that the category of a construct and the category of its head be identical, so that assigning *-ness* the category N has the effect of 'projecting' that category (rather than the category of the other constituent, the A *happy*) onto the construct *happiness*. Percolation also requires that other morphosyntactic features, such as gender and number, be identical for the construct and its head; Percolation then plays exactly the same role in morphology that the Head Feature Convention of Gazdar and Pullum (1982) plays in syntax. On this analysis, *happiness* belongs to the category N for the same reason that *those penguins* belongs to the category NP, that is, N-with-two-bars: because the head of each construct (*-ness* and *penguins*, respectively) is itself an N.

Now it would be sophomoric to criticize this analysis merely because its principal move, assigning *-ness* to the category N, is utterly untraditional and therefore astonishing. On the other hand, anyone who puts this analysis forward surely has some burden to show that there is a reason for believing in it beyond the one fact that it appears to get things to work.

What I will do here is give a summary of alternative definitions for the *head* of a syntactic construct and then consider how these proposals would extend to morphology. The short moral of this exercise is that there are several quite distinct and incompatible notions of *head* in syntax, and that not one of them extends in a satisfying way to morphology.

2. Heads in syntax

The intuition to be captured with the notion *head* is that in certain syntactic constructs one constituent in some sense 'characterizes' or 'dominates' the whole. From these basic ideas, however, it is possible to move in many directions, eight of which I consider below. The definitions in 2.1 (the distributional head), 2.5 (the head as governor), and 2.6 (the head as determinant of concord) are those mentioned in Crystal's dictionary (Crystal 1980, 172) and can be taken as the most traditional (though not,

of course, necessarily the most central) of the set. In addition, I take up the head as syntactic determinant (section 2.2), the head as the locus of inflectional morphology (section 2.3), the head as the obligatory constituent (section 2.4), the head of Dependency Grammar (section 2.7), and a semantic notion of head, the semantic argument (section 2.8).

To clarify the differences between the various definitions of head, I will examine what they say about the following combinations of constituents in English:

1. Det+N, as in those penguins
2. V+NP, as in control those penguins
3. Aux+VP, as in must control those penguins
4. P+NP, as in toward those penguins
5. NP+VP, as in we control those penguins
6. Comp+S, as in that we control those penguins

2.1. The distributional head

One proposal (pursued especially by structuralist syntacticians, and finding its most careful development in works like Harris 1951) is that the head characterizes the construct in the sense that it is the one constituent that belongs to a category with roughly the same distribution as the construct as a whole. In Bloomfield's (1933, 194) formulation, the head is the constituent that belongs to 'the same form-class' as the construct.

For there to be a head in this sense, the construct must have some constituent belonging to a category with roughly the same distribution as the construct--that is, the construction must be endocentric, in the traditional sense of this word. On this definition, only the first three of my example constructions have heads: N is the head of Det+N, since the distribution of the construct is roughly the same as the distribution of Ns like penguins and Kim; V is the head of V+NP, since the distribution of the construct is roughly the same as the distribution of Vs like write and vanish; VP is the head of Aux + VP, since the distribution of the construct is roughly the same as the distribution of VPs like control those penguins and go to Fresno. Because of these facts, on distributional grounds we assign Det+N to an 'N-type' category, namely NP; V+NP to a 'V-type' category, namely VP; and Aux+VP to a 'VP-type' category, namely some sort of VP.

In contrast, the P+NP construct has the distribution of neither P nor NP; instead, since it combines with V or with V and NP to make a construct of category VP (move toward those penguins, put the suntan lotion on those penguins), it has roughly the distribution of Adv. The NP+VP construct has the distribution of neither NP nor VP; instead, it has a unique distribution and is assigned to a new category S. The Comp+S construct has the distribution of neither Comp nor S; instead, since it combines with V to make a construct of category VP (realize that we control those penguins) and with VP to make a construct of category S (that we control those penguins astonishes everyone), it has roughly the distribution of NP.

(Though P+NP, NP+VP, and Comp+S are exocentric from a distributional point of view, some or all of them are treated as endocentric in certain current syntactic theories. In the version of Generalized Phrase Structure Grammar in Gazdar and Pullum (1982), for instance, all three are analyzed as endocentric: P and P+NP are both subcategories of P; VP and NP+VP are both subcategories of VP, hence also of V; and S and Comp+S are both subcategories of S, hence also of V. These category assignments play a crucial role in the placement of inflectional marks (see section 2.3 below). The assignment of P+NP to PP--that is, P with one or more bars--is very nearly universal among 'X-bar' syntactic theories (e.g., GPSG, Lexical Functional Grammar, Government and Binding Theory, Jackendoff's 1977 X-bar Syntax). The assignment of S and Comp+S as subcategories of one category is equally widespread. On the other hand, some analysts treat NP+VP exocentrically, as belonging to a category S distinct from V, while others treat it endocentrically, as a subcategory of V; see the chart summarizing eight different proposals in Gazdar et al. (1983, 3)).

2.2. The head as the syntactic determinant

The next version of head is one that has not been offered by any syntactician, to my knowledge. I mention it here because it is the closest analogue to the Lieber-type proposal for morphology.

The motivation for this definition in syntax comes from exactly those cases where the distributional definition plays no role, namely distributionally exocentric constructions like 4 through 6 above. The intuition about such cases is that one of the constituents 'dominates' the other and so 'determines' the category of the construct.

Now there are several ways of making the sense of 'determination' more precise; three are developed in sections 2.5 (the head as governor), 2.7 (the head of Dependency Grammar), and 2.8 (the semantic head). Here the idea is that for some constructs, one of the constituents, X, is pretty much restricted to this construct, while the other constituent, Y, occurs in a number of other constructs; as a result, from the occurrence of X in a construct we can determine that its sister constituent is Y, but not vice versa. Somewhat more precisely, on this definition the head of a construct is the constituent with the most restricted set of co-constituents.

The syntactic determinant in the P+NP construct is clearly P; NP combines (at least) with V, with VP, and with N (in the possessive construction of those penguins' bills), as well as with P, while P combines only with NP. On the same grounds, VP is the syntactic determinant in NP+VP. The case of Comp+S is not quite so clear, but the evidence is somewhat in favor of Comp as the syntactic determinant, since Comp combines only with S, while S combines (at least) with subordinating Conj as well.

It now turns out that the syntactic determinants in cases 1-3 are not entirely coincident with the distributional heads. In case 3, V is the syntactic determinant as well as the distributional head (for the same reasons that established P and VP as the syntactic determinants in cases 4 and 5). But in cases 1 and 2, the syntactic determinants are the distri-

butional modifiers, Det and Aux, rather than the distributional heads, N and VP, respectively; N and VP have wide privileges of combination, while Det and Aux are very restricted.

2.3. The head as the locus of inflectional morphology

Another way in which one constituent can 'characterize' a construct is that it can be the bearer of the inflectional marks of the syntactic relations the construct bears to other syntactic units. This is the crucial characteristic of the head in Generalized Phrase Structure Grammar.

The inflectional locus in our cases 1-3 is quite clear. N is the inflectional locus in Det+N; the distinction between singular the child and plural the children is linked to number distinction in VP. Aux is the inflectional locus in Aux+VP; the number and person distinctions in be/am/is/are/was/were controlling those penguins are linked to these distinctions in the subject NP. And V is the inflectional locus in V+NP, because of the person and number distinctions expressed in control/controls those penguins.

VP is perhaps the inflectional locus in NP+VP, and S in Comp+S. In the first case, person and number are marked on both the NP and VP, but only the VP bears the marks of tense. In the second, only S bears the marks of tense. The question is whether there are syntactic conditions linking the tense of S and/or S' to the tense of other units. If there are, then they decide the assignment of inflectional loci; if not, the question is moot.

English P+NP has no clear inflectional locus; the NP does bear the marks of person and number, but person and number play no role in the distribution of P+NP constructs. And English marks no grammatical categories on P.

(Given other assumptions in Generalized Phrase Structure Grammar about the principles distributing morphosyntactic features that will receive inflectional realization, the inflectional loci in these last three cases are clear: P is the inflectional locus in P+NP, VP in NP+VP, and S in Comp+S).

2.4. The head as the obligatory constituent

If the head of a construct characterizes that construct, then we should expect the head to be the part that is present in all its occurrences--that is, we should expect the head to be obligatory (and non-heads to be optional). Notice that this definition of head is closely related to the first (in section 2.1) and might be considered to be an extension of it to (some) syntactically exocentric constructions.

If this definition is to be usable in all but a tiny handful of cases, we must make a distinction between constituents that are optionally present and those that are elliptical. The NP of V+NP is optionally present; there are both transitive and intransitive verbs. Similarly, the Aux of Aux+VP

is optionally present; there are verb phrases with and without auxiliaries. The V of V+NP can, however, be an elliptic zero (as in I ate sushi, and Kiyoko a hamburger), and so can the VP of Aux+VP (as in I can swallow goldfish, but you can't). Speaking very crudely, elliptical constituents must be interpreted from context (linguistic or otherwise), but optionally present constituents require no such contextual interpretation.

With this background, we can review the six sample cases from English, to determine which constituent (if any) is the obligatory one.

For the three cases in which the criterion of section 2.1 picks out a distributional head, the criterion of obligatoriness agrees. In Det+N the N is the obligatory constituent; problems and rice are simply determiner-less NP's, but most noun-less NPs, like Timmy's and the pink, are elliptical. In V+NP the V is the obligatory constituent, and in Aux+VP the VP is the obligatory constituent, as I pointed out above.

Of the remaining cases, all except P+NP are reasonably clear. For Comp+S, S is the obligatory constituent, given that Comp does not occur without S, though S occurs without Comp in examples like I think the penguins are ready to eat. For NP+VP, the existence of subjectless imperative sentences like Hand me that dwarf!, in combination with the fact that a sentence consisting entirely of a NP (like Your desk chair) is understood as elliptical, means that VP is the obligatory constituent in NP+VP. As for P+NP, the evidence is both slight and contradictory, though somewhat in favor of P as the obligatory constituent. If prepositions and particles belong to the same category, in the fashion of Emonds (1972), then NP-less Ps are exemplified in VPs like put the penguin on. On the other hand, there are a small number of P-less NPs with adverbial function, among them home and there.

2.5. The head as governor

One obvious way for one constituent in a construct to 'dominate' another is for it to govern the other syntactically. Syntactic government, speaking rather loosely, is the selection of the morphosyntactic shape of one constituent (the governed, or subordinate, constituent) by virtue of its combining with another (the governor).

In the clearest examples of government, (at least some) instances of the category Y in an X+Y combination bear a mark (in particular, an inflectional mark) that Y does not bear in some other combinations, and X bears no corresponding mark.

In my six example constructions in English, the governors in V+NP, P+NP, and NP+VP are easily picked out on this basis. V and P are the governors in V+NP, P+NP, and NP+VP are easily picked out on this basis. V and P are the governors in V+NP and P+NP, respectively, and VP is the governor in NP+VP, since accusative forms of personal pronouns are required in the first two combinations, while nominative forms occur for NP in the third: control them, to them, but they fly. And V, P, and VP do not bear inflectional marks of case corresponding to the marks on the governed constituents.

The traditional notion of government is also extended to cases where a division of the category X into covert (inflectionally unmarked) subcategories is matched by overt inflectional marks on category Y. A typical instance of this sort of government occurs in languages (like German and Latin) in which some verbs combine with object NPs marked with one case (the dative, say), while other verbs combine with object NPs marked with a different case (like the accusative).

On this basis, Aux is the governor in Aux+VP. The English category of auxiliary verbs divides into several subcategories according to the inflectional form of the VP that follows, and the auxiliaries are themselves unmarked with respect to these subcategorizations: for instance, the modals combine with 'base', or 'unmarked infinitive', VPs (should control the penguins), progressive be with present participal VPs (are controlling the penguins), and passive be and perfective have with past participal VPs (are controlled by penguins, have controlled the penguins).

In a further extension of the traditional notion of government, it applies as well to examples in which a covert subcategorization in one constituent is matched by any overt difference in form in the other constituent, whether or not this difference is indicated by inflectional affixation. On this basis, N is the governor in Det+N, and Comp the governor in Comp+S. N is the governor because the covert count/mass distinction in singular Ns is matched by an overt lexical choice among determiners: few penguins, but little sand. Comp is the governor because the choice of one complementizer over another is matched by the selection of a finite or marked-infinitive form for the S with which Comp combines: that the penguins are flying, but for the penguins to be flying.

(I must point out here that with this last extension it is often difficult to decide which constituent governs which, and often difficult to distinguish government from concord.)

2.6. The head as the determinant of concord

Yet another sense in which one constituent can 'dominate' another is for the first to determine concord features, realized inflectionally, on the second.

The clearest examples of concord--subject-verb agreement in English is one such--are those in which the relevant feature is realized inflectionally on both constituents. What is not necessarily so clear even in these examples is which constituent determines concord; such English data as The penguin swims versus The penguins swim do not tell us whether the NP or the VP is the determining constituent for the purposes of concord. The existence of inherently-plural, but morphologically unmarked, nouns like people, together with the nonexistence of inherently singular, but morphologically unmarked, verbs, suggests that the NP is the concord determinant in English. And the NP-VP case is clearer in some other languages. In Swahili, for instance, nouns divide lexically into a number of gender classes, each marked overtly by a prefix on the noun; verbs occur with corresponding (often identical) prefixes, but each verb can occur with all of the prefixes. These facts indicate very clearly that the subject NP

is the determinant of concord on VP, and insofar as we are willing to propose that the direction of determination is universal, they suggest that NP is the concord determinant in English as well.

Taking up the five remaining English constructions on our list in order, now, we see that N is the concord determinant in Det+N, given English facts like this penguin versus these penguins and the clear directionality of determination in languages with arbitrary gender, like French and German. English gives no evidence about the concord determinant in V+NP, but languages like Hungarian, in which the verb carries marks agreeing with features of the object, suggest that NP is the concord determinant. English also gives no evidence in the cases of Aux+VP, P+NP and Comp+S, and I know of no relevant cross-linguistic evidence.

2.7. The head of Dependency Grammar

In approaches to syntax that take some generalized notion of 'dependency', rather than constituency, as the main theoretical primitive (see Matthews 1981, 78-84 for summary discussion, 94f. for references), some head-like notion plays a central role. In such a framework, a syntactic description is essentially a list of head-dependent pairs.

For syntactically endocentric construction, the Dependency Grammar head is the distributional head, and the dependent constituent is a modifier: N is the head in Det+N, V in V+NP, and VP in Aux+VP. For syntactically exocentric constructions, the Dependency Grammar head is the governor, and the dependent constituent is subordinate to the governor: P is the head in P+NP, VP in NP+VP, and Comp in Comp+S.

2.8. The semantic head: the head as the semantic argument

In traditional grammar, the head/modifier distinction is a semantic one: in a combination X+Y, X is the 'semantic head' if, speaking very crudely, X+Y describes a kind of the thing described by X. On this basis, N is the semantic head in Det+N (those penguins describes a kind of penguin), and VP is the semantic head in Aux+VP (will leave describes a kind of leaving).

A sharpening (and extension) of this proposal builds on the fact that in the semantic interpretation of Det+N, Det represents a function on an argument represented by N, and in the semantic interpretation of Aux+VP, Aux represents a function on an argument represented by VP. We might then propose that in X+Y, X is the semantic head if in the semantic interpretation of X+Y, Y represents a function on an argument represented by X.

If so, then in V+NP, P+NP, and NP+VP, NP is the semantic head, since the semantic interpretation of all three constructs involves applying a function (represented by V, P, or VP) to an argument represented by NP. And S is the semantic head in Comp+S, since the semantic interpretation of the construct involves applying a function to propositions as arguments.

One very distressing consequence of this way of looking at semantic

heads is that it picks out the constituents that are syntactically determined, in the sense of section 2.2 above. That is, syntactic determinants represent semantic functions, while the current proposal identifies 'semantic heads' as arguments. Starting from two different sorts of intuitively clear cases (VP as the syntactic determinant in NP+VP, and P in P+NP; N as the semantic head in Det+N, and VP in Aux+VP), we have reached exactly opposed notions.

3. Summary and evaluation

I now summarize in a chart how the eight notions of the previous section apply to our six test constructions:

Notion	Det+N	V+NP	Aux+NP	P+NP	NP+VP	Comp+S	
Distrib. Head	N	V	VP	---	---	---	
Syntactic Determ.	(Det)	(V)	(Aux)	P	VP	Comp	
Locus of Inflect.	N	V	Aux	(P)	VP	S	*
Obligatory Constit.	[N]	[V]	[VP]	(P)	VP	S	
Governor	N	V	Aux	P	VP	Comp	*
Concord Determ.	[N]	[NP]	?	?	[NP]	?	*
Dependency Grammar	[N]	[V]	[VP]	[P]	[VP]	[Comp]	
Semantic Argument	N	NP	(VP)	(NP)	(NP)	(S)	*

This chart presents a picture of great chaos. Things are not quite as hopeless as they first appear, however.

I have placed in square brackets entries that are simple duplicates of those appearing elsewhere. The head of Dependency Grammar is identical to the distributional head for endocentric constructions and to the governor for exocentric constructions. The determinant of concord is, in fact, identical to the semantic argument (see Gazdar and Pullum 1982, 30f., and the proposals of Keenan (1974) and Bach and Partee (1980) that they cite). The obligatory constituent in an endocentric construction clearly must be the one with the distribution of the whole construct. These entries may be disregarded, as redundant.

I have placed in parentheses another set of entries obtained by

extrapolation from clear cases to less clear ones. These entries too may be disregarded, as questionable.

Finally, I have marked with an asterisk those notions that I believe the grammar must represent directly. For the purposes of semantic interpretation, argument-expressions must be distinguished from function-expressions. For the purposes of inflectional morphology, the constituents that bear marks of government and concord must be picked out, and the locus of expression for these marks must be specified. These four notions are then the prime candidates for identification as 'head'; the most parsimonious solution would be to employ a notion that already figures in the grammar. Distributional heads, syntactic determinants, and obligatory constituents are in some sense represented in the grammar, but there is no reason to think that any grammatical rule refers to any of these notions, except insofar as it can be reduced to one of the other four ('syntactic determinant', for instance, can be reduced to 'semantic argument', since the two are complements of one another).

It might, of course, be necessary to add head as an additional primitive notion, but the burden of proof is on the person who proposes head as an additional primitive (to be identified with the distributional head, the syntactic determinant, the obligatory constituent, or some ninth notion I haven't discussed), rather than on the person who proposes to identify head with the locus of inflection, the governor, the determinant of concord, or the semantic argument (or with a compound notion like the head of Dependency Grammar).

4. Heads in morphology

Of the four notions that must be represented in grammar, two--the semantic argument (section 4.1) and the locus of inflectional morphology (4.2)--must clearly also be represented in morphology. A third--the governor (section 4.3)--plays a very limited role in morphology. The fourth--the determinant of concord--plays no role at all, because parts of words do not exhibit concord.

In addition to these three, in the following sections I will also consider three further candidates for the definition of head in morphology: the distributional head (section 4.4), the syntactic head (section 4.5), and the morphological determinant (section 4.6).

4.1. The head as semantic argument

The traditional notion of head in morphology is semantic in character. The area in which it is most clearly applicable is compounding: Christmas cookie has cookie as its head because a Christmas cookie is a kind of cookie. Extending the traditional notion from uncontroversially endocentric cases like Christmas cookie to word formation in general, we get the morphological correspondent to section 2.8 above: The head in word formation is the semantic argument.

On this proposal, the head in derivation is always the base rather than

the affix, since the affix represents a function applying to the argument represented by the base. This is as true of derivation that doesn't change the category of the base (as in blue-ish) as of derivation that does (as in blue-ness).

4.2. The head as inflectional locus

An account of morphology must indicate where in a word the marks of inflectional morphology are located, just as an account of syntax must indicate which word in a phrase the marks of inflectional morphology are located on.

In syntax, a mark of inflectional morphology makes a formal unit, a word in fact, with the stem it combines with. But in morphology, a mark of inflectional morphology only coincidentally makes a formal unit with the morpheme it is located next to. If morphology were like syntax in its treatment of inflectional loci, we would expect the internal structure of unhappinesses to be [un + happy] + [ness + es], with the (inflectional) plural suffix forming a unit with the neighboring (derivational) suffix ness. But this is not the division called for by morphology/syntax/semantics--though it is just about the division needed in phonology, as Aronoff and Sridhar (1983) have observed.

The point here is that the grouping of morphemes into formal units might not be identical to the grouping of material into phonological units. This position has been generally accepted as it applies to phrasal syntax and phrase phonology, and it has long been recognized that an analysis of this sort is required for clitics (like the English possessive 's) which are distributed with reference to syntactic phrases (in the English case, at the end of a NP) but attach phonologically to whatever word they happen to be adjacent to. But it is only recently that this view has been taken (most forcefully by Selkirk (e.g. 1980)) in morphology.

The proposal for unhappinesses then is that for the purposes of morphology and semantics it has the left-branching internal structure

[[un + happy] + ness] + es]

but that for phonological purposes it consists of two binary feet. The 'phonological purposes' in question are two: First, the division unhappy + nesses is the appropriate one for the assignment of prosodic features, in particular stress; and second, this division is the appropriate one for the selection of irregular inflectional formations in cases like maple leaves and baby teeth.

All that needs to be said about the locus of inflectional morphology in English is that inflections are suffixes--that is, they come at the end of a word, whatever the morphological or semantic relationships among the other morphemes in the word. The indifference of inflection to the internal organization of words is perhaps clearest in English compounding, where there are many relationships among the constituent words (compare Christmas cookie, pickpocket, blackbird, step-in, producer-director), but all types of compounds have plurality marked on the last word: Christmas

cookies, pickpockets, blackbirds, step-ins, producer-directors.

What I am then saying about unhappinesses is that -ness is its apparent inflectional locus only because it happens to be the last morpheme in unhappiness.

The case for the locus of inflectional morphology as the head constituent of a word might seem to be stronger in languages with grammatical gender; thus Bauer (1983, 30) identifies the 'grammatical head' in endocentric compounds as 'the element marked for number, and also, in languages which have grammatical gender, the element that determines the gender of the compound'. In German, for instance, a final derivational suffix like -tum in Christentum 'Christendom' determines the (arbitrary) gender of the derived word, in this case neuter. It also determines the (equally arbitrary) declension class of the combination, and so determines which of several available plural markers occurs; in this case it is the plural in -er (which is accompanied by umlaut): Christentuemer.

The issue here is, however, not the location of inflectional marks, but rather morphological determination, which I will take up in section 4.6 below.

Now consider the parallel facts in German compounding. A compound like Landsmann 'compatriot, countryman' has its plural marked on the last element, Mann. Consequently, the declension class of the compound (it is again a plural in -er) is that of the last element (Mann takes a plural in -er). And the gender of the compound, too, is that of the last element; Landsmann is masculine because Mann is masculine. This last fact, however, does not follow from the location of inflectional affixes. For the purposes of adjective agreement (neues Christentum 'new Christendom', but neuer Landsmann 'new compatriot'), the whole compound word Landsmann must be specified as belonging to the masculine gender, but this specification is not achieved by a statement that the inflectional locus is the end of the word. We have another case of morphological determination, to be discussed in section 4.6.

4.3. The head as governor

In a small class of cases, one of the items combining in word formation bears a mark analogous to the inflectional marks of government in syntax. The other, unmarked, item is then the governor.

In English (and German and Dutch) noun-noun compounding, one noun sometimes occurs with a suffix that is formally identical to the plural or genitive suffix, both when this mark would be semantically appropriate (as in publications list, with a plural, and cat's paw, with a genitive) and when it would not (as in the examples bondsman, kinsman, landsman, marksman cited by Bloomfield (1933, 230)). The marked noun is always the first of the pair, indicating that the second is the governor.

4.4. The distributional head

Distributional heads of words can be determined in the same way as distributional heads of phrases; as in section 2.1, this notion of head is necessarily rather limited in its applicability.

Most English derivational formations do not have a distributional head, because they are category-changing; blueness lacks a head, since neither the adjective blue nor the suffix -ness has roughly the distribution of the noun blueness. Some English compounds also lack distributional heads; in step-in, neither the verb step nor the particle in has roughly the distribution of the noun step-in.

Category-preserving derivational formations do have distributional heads, and these are of course the bases; bluish and blue have roughly the same distribution. (In some cases it is not at all clear whether the formation is category-preserving or category-changing: Does the abstract noun kingdom belong to the same category as the animate noun king?) Most English compounds also have distributional heads, so long as 'distribution' and 'same category' are understood narrowly; sugar cookie has the head cookies on this interpretation, because sugar cookie is a count noun like cookie, not a mass noun like sugar, and Christmas cookie has the head cookie on this interpretation, because Christmas cookie is a common noun like cookie, not a proper noun like Christmas. In general, the second noun is the distributional head of a noun-noun compound in English.

4.5. The syntactic head as morphological head

Bloomfield's (1933, 233ff.) classification of compounds adopts still another approach to heads in morphology, one that builds directly on a syntactic notion of head (for Bloomfield, the syntactic notion is the distributional head). A variant of this idea appears in Lees' (1960) treatment of compounds, in which they are derived by transformation from syntactic combinations.

On this proposal, the head of pickpocket is pick, because the verb is the distributional head in a syntactic combination like pick pockets; the head of step in is step, because the verb is the distributional head of in a syntactic combination like step in; and the head of blackbird is bird, because the noun is the distributional head in a syntactic combination like black bird. The proposal extends to cases where morphological formations do not preserve syntactic word order: keep is the head of upkeep because it is the distributional head in keep up; knob is the head of door knob because it is the distributional head in knob of a door; and bake is the head of cookie baker because it is the distributional head in bake cookies.

Copulative compounds like producer-director either have two coordinate heads (Bloomfield's proposal, which assumes that phrases like producer and director have multiple heads) or none (if we insist that the distributional head is the one constituent belonging to a category with the distribution of the category of the whole construct).

The proposal has no obvious extension to derivation rather than compounding. On the one hand, we might say that derivational formations simply lack heads in this sense. On the other hand, we might use Bloomfield's implicit assumption that derivational affixes are not syntactic elements, in which case the base is always the head in a derivational formation, because it is the only syntactic element in the combination.

4.6. The head as morphological determinant

I now return to the proposal of Lieber et al. outlined in section 1 above. The use of Percolation to determine the category and morphosyntactic features of the construct in word formation requires that the head be the morphological determinant, a notion that is entirely parallel to the notion of syntactic determinant in section 2.2 above. In English (and German) the morphological determinant in a derivational formation involving a suffix is the suffix, and the morphological determinant in a compound is its rightmost member.

In some cases the appearance of morphological determination is simply a result of the fact that rightmost elements in words are inflectional loci. We would not want to say that the 'plurality' of the suffix -ness in sadnesses or the second word cookie in Christmas cookies determines the plurality of the whole word. Rather, we want to say something that is very nearly the converse: The plurality of the whole word is expressed by inflectional marks located on the rightmost element.

In other cases, however, there is clear morphological determination. As I observed in section 4.2, both the gender and the declension class of a German derived noun like Christentum are predictable from the occurrence of the particular suffix -tum in the word, and the gender of a compound like Landsmann is predictable from the occurrence of the particular word Mann as the second word.

Morphological determination in derivation, like syntactic determination generally, resides in the material representing the semantic function. If we adopt a 'rule-to-rule' semantics in word formation (as is generally assumed in Montague-style semantics for syntactic combinations), then to a word formation rule there corresponds a principle of semantic interpretation describing the meaning of the whole on the basis of the meanings of the parts. The connection between semantic function and morphological determination in derivation is then natural, for both concern the outputs of the rule: (a) 'morphological determination' is the specification of the morphosyntactic properties of the word resulting from the rule (for German Christentum, for instance, the rule affixing -tum specifies that the resulting word is neuter and belongs to the -er declension class); and (b) the 'semantic function' is the specification of the semantic interpretation of the word resulting from the rule, which in the case of derivation is exactly what is conveyed by the affix.

For derivation, then, the morphosyntactic properties of the whole are connected to the semantic function conveyed by the affix.

Things are different in compounding. Here the morphological determinant is usually the word representing the semantic argument. In the German compound Landsmann, Mann is the 'semantic head', that is, the argument; a Landsmann is a kind of Mann. One might argue that even in exocentric compounds like Rotdorn 'pink hawthorn' (i.e. tree with red thorns) the final member is the semantic head. But the real generalization is not that the semantic argument is the morphological determinant; rather, it is that any noun that is the final member of a compound is the morphological determinant. In cases like the neuter Vergissmeinnicht 'forget-me-not' (ending with the negator nicht) and the masculine Schlagetot 'hulking brute' (ending with the adjective tot 'dead'), the gender of the whole is in no sense determined by the final member--or by any other member, for that matter.

Such cases are admittedly rare in the world of German compound nouns, and might easily be treated as isolated lexicalizations. A more regular, and more telling, case is provided by the 'copulative', or dvandva, compounds of Sanskrit. In these compounds two or more noun stems are concatenated, and the whole is understood as if the constituent words were conjoined. With respect to morphological determination, there are two schemes: according to Whitney (1889, sec. 1253), either 'the compound has the gender and declension of its final member, and is in number a dual or a plural, according to its logical value' (devāsurās 'the gods and demons'), or 'the compound, without regard to the number denoted, or to the gender of its constituents, becomes a neuter singular collective' (ahorātram 'a day and night'). In the first scheme, we have the same system as German for gender, though number is determined semantically. In the second scheme, gender and number and declension class are all determined, not by some constituent word, but by the rule that combines words.

(Here I am inclined to say that the rightmost element is indeed the head in the formation of most German and Sanskrit, and for that matter English, compound nouns, but not in the second type of dvandva compound in Sanskrit (or in German compound nouns not ending in a noun, if there are any productive types of these), or in suffixal derivation in general. We then need the Head Feature Convention to apply in these cases--perhaps under the name 'Percolation'--but not in word formation in general).

5. Evaluation

Now to evaluate the two prongs of the Percolation proposal, the assumption that the morphological head is the inflectional locus and the assumption that the morphological head is the morphological determinant.

5.1. The inflectional locus assumption

As I stressed above, within English words the locus of inflection can be briefly described as 'at the end', or more precisely, as 'affecting the rightmost morpheme'. The Percolation proposal achieves conceptual economy by identifying the rightmost morpheme as the head, thus avoiding any need to distinguish two different types of ordering principles in morphology--

one type referring to heads, another type referring to the margins of the word.

Here the parallel with syntax breaks down. Syntactic principles locating inflectional morphemes always refer to heads, never to margins (that is the whole point of the Head Feature Convention of GPSG), and syntactic heads are only coincidentally located at one margin of their phrases. On the other hand, there is a class of morphemes some of which are located on heads, some at margins; these are the (special) clitics (see the summary discussion in Zwicky 1977). Finally, morphological principles locating inflectional morphemes seem always to refer to margins, never to morphological constituents that would constitute heads on any traditional definition; saying this is only rephrasing the traditional dictum that inflectional affixation takes place outside word formation, at the margins of the word.

I conclude that it would be (in general) ill-advised to attempt to exploit the 'head' of the Head Feature Convention as the inflectional locus for Percolation, and that any saving in conceptual apparatus that would follow from such a move is a false economy.

5.2. The morphological determinant assumption

Here the parallel with syntax is quite solid. The problem is that there is not the slightest indication that determinant is an adequate reconstruction of the notion of head in syntax. As my summary discussion in section 3 above indicated, the syntactic determinant is not identical to any of the constituents picked out by the notions that must play some role in syntax (the locus of inflection, the governor, and the determinant of concord).

Worse, even if the notion of determinant plays some role in syntax, it is conceptually dispensible, since syntactic determinants are simply semantic functions.

Now there are facts to be described here. An adequate description of word formation must somehow say that the category of a derived word is determined by the affix. But consider the case of compounding. However head-like the rightmost member of a compound might be for the purposes of locating inflectional morphology, it does not actually determine the category of the compound; noun-final compounds can be nouns (red-head), adverbs (bareback in She rode bareback and without any reins and uphill in They traveled uphill for six hours), or measure adjectives (three-dollar in a revolting three-dollar dinner), at least. What we should want to say about compounding is the very traditional proposal that there are a number of compounding rules. Each rule involves (a) the operation of concatenating two words, (b) these words belonging to specified categories, (c) with the result of the operation being a word of a specified category; moreover, with each rule is associated a principle of semantic interpretation for the compounds it provides.

Derivational affixes might indeed be more univocal in their morphological consequences than rightmost elements of compounds. What is at issue is

the analysis of facts like the following: English -al combines with verbs to form nouns (arrival) and with nouns to form adjectives (herbal); -ful combines with nouns to form adjectives (careful) and with nouns to form nouns (handful); stressless -ate combines with nouns to form nouns (protectorate) and with nouns to form adjectives (passionate); and zero derivation creates a whole series of types of deverbal nouns and another of denominal verbs.

These derivational cases are much less convincing than the compound cases, because alternative analyses are available. It is certainly possible that each of the 'affixes' I have listed is really a pair of homophonous affixes, especially when we consider how the semantics of affixation is to be described. And several writers (including Lieber 1981, ch. 3) have denied that English has any rule of zero derivation for noun-verb pairs, though it does have homophonous noun-verb pairs in its lexicon.

Primarily on the basis of the compound cases, I conclude that morphological determination resides not in a formative, but in an operation, or rather, in a rule performing an operation; for compounding, the operation is the concatenation of two operands, and for affixal derivation, the operation is the concatenation of material at one end or the other of an operand. (A similar position can be maintained for syntactic determination as well; see especially the discussion in Carlson 1983.) The apparently determinant formative in compounding is only one of the operands, and the apparently determinant formative in affixal derivation is merely a concomitant of the operation. This approach permits a single formative to be an operand in distinct operations, or to be a concomitant of distinct operations.

5.3. Process morphology

A special problem arises with the inflectional-locus and morphological-determinant conception of head in languages with derivational 'process' morphology. What are we to say about a language (like several of those cited by Marantz 1982) in which reduplication serves as the sole mark of derivation? Or a language (like German) in which ablaut patterns can so serve? Similar questions arise for umlaut, tone shifts, and consonant shifts, and related questions attend infixation, discontinuous affixation (like the German past participle ge-...-t/-en), and subtractive formations.

A piece of derivational process morphology is an inflectional locus, and it is also a morphological determinant, but it isn't a simple formative that attaches to a base. For Percolation to function equally for process morphology as for affixation, we apparently have to abstract 'process morphemes' that combine with bases (as Joseph and Wallace (1984, sec. 1)) have observed in their criticism of Williams 1981). The Percolation treatment of inflectional loci and morphological determination apparently obliges us to hew to an agglutinative approach to derivational morphology, and so gives rise to such pseudo-questions as whether an instance of ablaut derivation in German involves a prefix or a suffix. Unadorned, the Percolation treatment calls up the full range of problems that process morphology posed for structuralist morphologists.

The recent literature contains several alternatives to an agglutinative treatment of process morphology. In a couple of these Percolation has a natural place, but in others the effect of Percolation is achieved by two independent mechanisms.

There is the nonagglutinative proposal of Williams (1981), who calls for 'headless' word formation in cases like the English noun-verb pairs exemplified by breath-breathe, life-live, and bath-bathe. Here the effect of Percolation is split, with Percolation itself doing the job for affixal derivation, and some other mechanism (not explored by Williams) doing the job for process derivation.

Another view, suggested by Lieber (1981), is that the allomorphs related by process morphology should simply be listed in the lexicon, and should be associated with one another by (nondirectional but context-sensitive) 'morpholexical rules'. Again, the effect of Percolation is split, with Percolation itself working in affixal derivation, and a feature-assignment mechanism working in process derivation (base forms are assigned the value [-F] and derived forms the value [+F], and the two are related by a morpholexical rule).

Another, proposed especially by McCarthy (1981, 1982), merges the 'long component' treatment of discontinuous morphology advanced by Harris (1951) with the 'autosegmental' approach to phonology proposed by Goldsmith (1976). In this 'prosodic" view of process morphology, process morphemes are represented separately from their bases, but the operation combining them is not agglutination, but rather superimposition; the base and the process morpheme lie on separate 'morphemic tiers', in a dimension orthogonal to the left-to-right linear ordering of segments and of affixal morphology. McCarthy has not, so far as I know, explored how Percolation would be managed in this framework, but it is easy to find a natural place for it, since derivative word formation in this framework is simply the combination of base and affix, in either of the two dimensions the framework provides. It follows that word structures are three-dimensional objects, rather than the two-dimensional tree structures of orthodox morphological analysis.

Marantz (1982) advocates a mixed approach, in which a prosodic analysis is appropriate for some phenomena, a morpholexical-rule analysis for others.

Still another idea (along the lines of Schmerling 1983) involves distinguishing, Montague-fashion, the notion of grammatical rule from the operation that the rule performs. Concatenation of material to (one end or the other of) a base is one operation that a rule could perform, but there are others: the rule could 'wrap' the base around some material (infixation); it could duplicate some of the substance of the base (reduplication); it could alter phonological features of the base in a systematic way (or simply mark the base as being subject to a particular phonological rule); or it could perform several of these operations in concert. One attractive feature of this approach is that it embodies the observation (much stressed by Lieber (1981)) that a single operation typically plays a number of diverse roles in the morphology of a language, often functioning in both derivational and inflectional morphology; a single reduplication

operation, for instance, might be an exponent of a rule deriving causative verbs from adjectives, an exponent of a rule deriving intensive verbs from simple verbs, and an exponent of plural inflection on nouns. A less attractive feature is that, unless more is said, this framework permits powerful morphological 'transformations', of the sort that the approaches of Lieber, McCarthy, and Marantz were designed to avoid. In any case, the effect of Percolation would be achieved in this framework by assigning the 'head features' to the rule itself, hence to the semantic function associated with the rule; but there would in general be no affixes to serve as the 'heads' of anything, since affixes would merely be concomitants of the operation performed by the rule.

Only McCarthy's prosodic proposal and the Schmerling-style rule/operation proposal treat the morphological-determination aspect of Percolation in process morphology as a unitary phenomenon. The first requires a novel three-dimensional view of word structure but is otherwise consistent with a single principle of Percolation. The second allows the more traditional two-dimensional view of word structure but dispenses with Percolation entirely.

6. Conclusion

I have argued that there are several good candidates for the notion of 'head' in syntax, but that the syntactic determinant is not one of them. The head for the purposes of the Head Feature Convention is a variant of the inflectional locus, which is one of the good candidates.

In attempting to extend the Head Feature Convention to morphology, proponents of Percolation have carried over the idea that the head should be the inflectional locus--but the locus of inflection in morphology is at one of the margins of the word, not on any morpheme that could independently be argued to be the head of the word--and added the proposal that the head is also the morphological determinant.

Examining the idea that the morphological determinant is the head of a word, I argued that morphological determination resides not in formatives, but in rules performing morphological operations. Morphological determination is then, via the association between rules and semantic functions, associated with a particular semantic function.

It follows that the notion of 'head' incorporated into Percolation is inadequate for both of its intended purposes, (a) locating marks of inflection and (b) determining the category and morphosyntactic features of a word.

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